have tried to explain, by analysis, the production of the five images observed by me, but was obliged to give it up on account of the complexity of the calculations. In the case of three images, Bravais also shows how only certain parts of an object can produce multiple images; this phenomenon actually occurs as we have seen above.

Finally, if we reflect that two layers of air of very different densities cannot remain for a long time superposed one upon the other without becoming mixed, we shall understand the instability of the phenomenon and why the fata morgana and the mirage on cold water can succeed each other so rapidly in the same part of the lake.

An excellent description of the fata morgana as seen from Reggio, on the Italian coast, when looking toward Messina across the Straits of Messina, is given by Mascart in the third volume of his Treatise on Optics, Paris, 1893. In this volume (pages 305–338) he also gives a complete elucidation of the optical principles involved in every form of mirage, including even the triple images of vessels in the distant horizon, the multiple images observed by Arago and Biot, and every form of fata morgana. Mascart's formula seems to us applicable to all the cases enumerated in the above quotations.

## AN EXPERIMENTAL RAINFALL.

A letter of June 20 from Prof. L. Errera, of Brussels, is published in *Ciel et Terre* for August, 1896, XVII, p. 353, giving the following description of an experimental study into the formation of clouds, which will, we hope, attract the attention of physicists who are conducting advanced courses in meteorology in American colleges and universities. The experiment has been repeated at the Weather Bureau with success, but it should be carried out on a large scale, with a very tall jar and great care as to uniformity of temperature, if one desires to get satisfactory results. Probably the clouds can be photographed by using a flash light and with care in the illumination. Other liquids, such as ether, benzine, turpentine, and water, should also be tried:

Take a cylindrical vase of bohemian glass of about 20 centimeters in height and 12 in diameter and fill it half full of strong alcohol—92 per cent—and cover it with a porcelain saucer and warm it over the water bath. It is necessary to warm it up for quite a long time, in order that the liquid and the whole vase and the porcelain cover may attain a high temperature and be in thermal equilibrium among themselves, but without bringing the alcohol to the boiling point. Remove the whole from the warm place and, being careful not to agitate the liquid, place the vase upon a wooden table and observe it carefully. The warm liquid continues to send up an abundance of alcoholic vapors. After some minutes the porcelain cover is sufficiently cooled so that these vapors commence to condense in its immediate neighborhood. Soon there are thus formed clearly visible clouds, and these in their turn resolve themselves into very fine droplets of rain, which fall steadily, vertically, and in countless numbers into the liquid. The droplets, when measured by means of a horizontal microscope, have an average diameter of from 40 to 50 thousandths of a millimeter; they are sometimes larger but more frequently smaller. This interesting spectacle may last for half an hour.

At first the vapors rise quite up to the porcelain cover, but in proportion as the whole system cools down the level where the condensation occurs naturally lowers more and more, and now we find a perfectly clear zone above the zone of clouds. We have in this way in miniature the whole aqueous circulation of the atmosphere; the evaporating liquid represents the ocean, far above it the cooling porcelain saucer is the pure sky, below this the clouds, which resolve themselves into real water, and the latter returns to the ocean. Except that in place of water everything is made of alcohol.

It would be surprising if this simple phenomenon has never been described before; but as you say that you do not remember to have seen an account of this anywhere in the meteorological literature, with which you are so perfectly familiar, I think it well to explain the conditions under which the phenomena are produced.

[The experiments here described by Errera may be compared with the well-known similar work of Tyndall and Aitken, especially those described by the well-known physicist of Edinburgh in his memoir entitled "On dust, fogs, and clouds." (Edinb. Transactions, 1880–81, XXX.) But Aitken makes use of complicated apparatus, while the experiments of Errera can be repeated at any time and in the simplest manner. Moreover, Errera describes very interesting phenomena that Aitken did not perceive, or, at least, has passed over in silence. Tyndall considers an analogous subject in his note "On the formation and phenomena of clouds." (Roy. Soc. London Proceedings, 1869, XVII.)—A. Lancaster.]

Possibly this experiment may serve to explain some meteorological problems that are still under discussion; for example, whether the production of rain is necessarily subordinated to electrical influences, as is acknowledged by Clement Ley and many other authors.

Our experiment is, moreover, susceptible of several variations. After having taken the vase from the warm bath, if we replace the warm porcelain cover by a cold one the differences of temperature between different points of the system become greater and the phenomena are exaggerated; little whirlwinds, which are true squalls, are produced. When the alcohol is still very warm and if, by accident, the vase is a little warmer on one side than on the other, in that portion which is above the level of the liquid we see the alcoholic vapor performing a regular rotation about a horizontal axis; it continually rises along the warmer side of the vase and descends along the colder side. The proof that this rotation is due to the cause that I suggest is, that in order to reverse the direction of the rotation it suffices to cool the side of the vase along which the vapors are rising and this is easily done by the application of a strip of filter paper wet with cold water and frequently renewed.

At first thought the formation of cloud and rain in Errera's experiment where there can be no dust particles to serve as nuclei for condensation, seems to be contrary to Mr. Aitken's theory and experiments, according to which all ordinary rains and clouds depend upon the presence of dust nuclei; but there is really no contradiction. When air is cooled to a temperature near dew point, condensation begins where it is most easily possible, viz: first, on hygroscopic surfaces and next to this, on small particles of dust, many of which are also hygroscopic and, finally, on those that are smallest, even though they be not specially hygroscopic. If cooling proceeded only thus far, we should have dew, fog, and cloud, but no rain. If the process of cooling still continue then a certain critical stage is passed over and the aqueous molecules begin to agglomerate without waiting for the presence of nuclei; they come together in larger drops and by a more violent process. The extent to which cooling must proceed in order that this form of condensation may begin has been investigated, and may be defined as follows: If the cooling is produced by expansion, then the amount of expansion required in order to produce the second stage of condensation is 1.258 times the expansion necessary to produce the first stage of condensation. (See Monthly Weather Review, May, 1896, page 167.) As long ago as 1841 Espy (see his Philosophy of Storms, page 35) observed the fact that when, by expansion, we determine the dew-point for a mass of air contained within a glass jar, several times in succession, the dew-point seems to be steadily rising. He says:

On comparing together the experiments made on dry air, there appeared but little discrepancy, but with moist air this was not so, and I was induced to institute a set of experiments to see whether length of time had any influence on the result. I, therefore, performed a great number of experiments similar in all respects, except the length of time which intervened between the time of pumping air into the nephelescope and of letting it out, and, to my astonishment, I found the rise of the mercury, after the discharge, constantly greater as the time was longer, up to about twelve or fifteen days; but beyond that time the effect did not seem to be increased. It follows from these experiments that when air saturated with vapor is confined in a glass vessel, air-tight, and containing a small portion of water, it will cease to be saturated to the amount of four or five degrees in the dew-point in fifteen days. Whatever may be the cause of this remarkable fact, so contrary to all our notions, since the experiments of Dalton on the subject of the dew-point, the following table of experiments proves beyond all doubt that it is a fact. Does water or glass so attract the particles of aqueous vapor as to condense some of these particles on them and bring down the dew-point four or five degrees below the temperature of the water and of the air included in the vessel?

The Editor can not doubt that Professor Espy was here in presence of the phenomenon that has subsequently been investigated by Barus and C. T. R. Wilson. By allowing his air to stand so long it had, by washing and settling, lost the greater part of its original dust. The dew-point determined by Espy, at the beginning of any experiment, corresponded to the first stage of cooling and the formation of fog on dust nuclei; but the dew-point determined by him a few days later in the same air when it had become dustless by settling represented the second stage when the vapor particles must condense on themselves only, which process required a greater cooling and a greater expansion.

## MEXICAN CLIMATOLOGICAL DATA.

In order to extend the isobars and isotherms southward so that the students of weather, climate and storms in the United States may properly appreciate the influence of the conditions that prevail over Mexico the Editor has translated the following tables from the current numbers of the Boletin Mensual as published by the Central Meteorological Observatory of Mexico. The data there given in metric measures have been converted into English measures. The barometric means are as given by mercurial barometers under the influence of local gravity, and therefore need reductions to standard gravity, depending upon both latitude and altitude; the influence of the latter is rather uncertain, but that of the former is well known. For the sake of conformity with the other data published in this REVIEW these corrections for local gravity have not been applied.

*Mexican data for August, 1896.*

| Stations. | Altitude. | Mean barometer. | Mean temperature. | Relative humidity. | Precipitation. | Prevailing direction. Wind. | Prevailing direction. Cloud. |
|---|---|---|---|---|---|---|---|
| | *Feet.* | *Inch.* | ° *F.* | % | *Inch.* | | |
| Colima (Seminario) | 1,291.7 | 28.30 | 80.1 | 73 | 6.54 | sw. | |
| Colima | 112.2 | ...... | 80.6 | ..... | ...... | ......... | |
| Guadalajara (Obs. d. Est.) | 5,188.0 | 25.03 | 69.6 | 89 | 14.92 | ......... | e. |
| Guanajuato | 6,761.3 | 23.74 | 67.8 | 53 | 3.76 | ene. | ne. |
| Jalapa | 4,757.3 | 25.61 | 68.0 | 87 | 8.02 | n. | |
| Lagos (Liceo Guerra) | 6,274.5 | 24.20 | 69.1 | 58 | 2.49 | ne. | ne. |
| Leon | 5,901.0 | 24.35 | 70.0 | 54 | 1.81 | se. | e., ene. |
| Magdalena (Sonora) | ....... | ...... | 82.6 | ..... | 19.57 | s. | |
| Mazatlan | 24.6 | 29.91 | 84.7 | 77 | 3.38 | nw. | ne. |
| Merida | 50.2 | 29.97 | 81.1 | 78 | 7.83 | ne. | e. |
| Mexico (Obs. Cent.) | 7,488.7 | 23.12 | 63.0 | 65 | 2.56 | nw. | ne. |
| Mexico (E. N. de S.) | 7,480.5 | 23.11 | 63.1 | 65 | 2.56 | ......... | |
| Morelia (Seminario) | 6,401.0 | 24.01 | 62.8 | 72 | 4.71 | ssw. | e. |
| Oaxaca | 5,164.4 | 25.11 | 73.0 | 61 | 2.39 | nw. | ne. |
| Pabellon | 6,312.4 | ...... | ...... | ..... | ...... | ......... | |
| Pachuca | 7,956.3 | 22.59 | 57.9 | 66 | 0.27 | ne. | ne. |
| Puebla (Col. Cat.) | 7,112.0 | 23.43 | 67.1 | 55 | 2.29 | ......... | |
| Queretaro | 6.069.7 | 24.23 | 68.5 | 62 | 2.00 | e. | e. |
| Saltillo (Col. S. Juan) | 5.376.7 | ...... | ...... | ..... | ...... | ......... | |
| San Luis Potosi | 6,201.9 | 24.22 | 69.4 | 62 | T. | ne. | e. |
| Silao | 6,063,1 | 24.31 | 71.6 | 68 | 2.64 | ne. | ne. |
| Tacubaya (Obs. Nac.) | 7,620.2 | ...... | ...... | ..... | ...... | ......... | |
| Toluca | 8,612.4 | 21.96 | 59.0 | 67 | 3.00 | se. | e. |
| Trejo (Hac. Silao, Gto.) | ....... | ...... | ...... | ..... | 3.20 | ......... | |
| Zacatecas | 8,015.2 | 22.67 | 65.7 | 60 | 1.59 | e. | e. |
| Zapotlan (Seminario) | 5,124.8 | 25.11 | 70.7 | ..... | 7.14 | n. | n.e |

## UNRELIABLE POPULAR WEATHER PROVERBS.

Many persons still fail to realize the fact that the weather proverbs which pass down from generation to generation as unquestioned as are the nursery stories, belong to what may be properly called mythology. Like the myths and legends of ancient times they may, possibly, have had some slight basis of fact; they may possibly have applied satisfactorily to some far off period and some far distant land, or to one special occasion, but do not, necessarily, hold good to-day and in our own country. At a recent meeting of the Meteorological Society of France the members discussed the popular proverb: "When it rains on St. Medard's day it will rain for forty days unless fine weather returns on the day of St. Bernabe." M. Teisserenc de Bort showed that M. Lancaster, who, several years ago examined this question, found no results tending to verify this saying. M. Teisserenc de Bort has also studied the question as to whether it was possible to predict in advance a rainy period; thus in examining the data collected from 1863 to 1896, he finds that in the first days of June the rain is, on the average, a little more abundant, and diminishes toward the end of that month. But it was not observed that there was any systematic grouping of the days of rain around the day of St. Medard.

M. Renou said that M. Elie de Beaumont has called attention to the fact that the proverb relative to St. Medard dates from the middle ages, and that since then the order of the saint's days in the calendar has been changed, and that now the day of St. Gervais is the one to which the proverb should be applied. M. de Beaumont, therefore, examined the question of the grouping of days of rain according to the new date but did not find any verification of the proverb.

## THE EFFECT OF SHADING THE SOIL.

According to Lancaster (*Ciel et Terre*, March, 1896, XVII, p. 22), some experiments have been made by A. Buehler, which may be summarized as follows: Four broad plats of ground were selected, situated near each other; one was left freely exposed to the sun and wind while the three others were shaded by horizontal wooden trellises placed around each plat and about 40 centimeters above the ground. The sunlight was cut off from the ground by the shadow of the trellis to a different extent for each plat, viz, one-quarter for plat No. 2, one-half for No. 3, and three-quarters for No. 4. In each plat, at 5 centimeters below the soil, a thermometer was buried; there was also placed in each plat an evaporometer and a vase of sheet iron filled with clay in which 1,000 grams of water had been poured. Observations were taken every three hours, with the following results: The shaded soil experienced less cooling by radiation at nighttime and less warming by sunshine in the daytime. The plat, No. 4, three-fourths of whose area was shaded, showed a temperature 10 per cent lower than the unshaded plat, No. 1; the lowering of temperature was most decided at noon and 3 p. m. As to the nocturnal cooling, the differences between the various plats were only 2° C. at the maximum, which explains why plants under a trellis are less exposed to frost than plants that are not thus protected. During rainy weather the differences in temperature were very small, rarely more than 1° C.; the shaded plats had a temperature a little higher than the unshaded, but during dry weather the shaded plats were warmed up more slowly. The relative evaporation from the plats was as follows: No. 1, unprotected, 100 per cent; No. 2, one-quarter covered, 88 per cent; No. 3, one-half covered, 71 per cent; No. 4, three-quarters covered, 62 per cent. Evaporation was most rapid from noon to 3 p. m. The observations all relate to a soil that is not covered with vegetation. If the soil had been cultivated the temperature and the evaporation would have been diminished still more.

## A PRIZE FOR KITE FLYERS.

Owing to his great interest in everything bearing on aeronautics, Mr. Octave Chanute, of Chicago, recently authorized the Boston Aeronautical Society to invite competition for a special prize for the best monograph on the kite, giving a full theory of its mechanics and stability, with quantitative computations appended; the prize to be awarded by judges appointed by the Society. It was originally intended that the competition for this prize should close on November 15, 1896, but by a recent circular of November 23 we learn that the date has been postponed to January 1, 1897. Doubtless many of our readers will have interested themselves in kite flying for scientific purposes sufficiently to have, at least, thought of competing for this prize. The kite promises to become a very important factor in the exploration of the atmosphere and we shall all look forward with interest to the publication of that prize essay.

About 1880 the Editor found a lad in Washington who had kept his kite in the air continuously for the greater part of two days and could have kept it there for a week longer. Up to that time the Editor had used and thought of the kite only as a means of getting occasional records of the condition of the upper currents, but ever since that date he has